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Acquiring 21st Century Blitzkrieg via Physic-Based Gaming

4/24/2014

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Agenda



- ESP in Systems Engineering
- Whole System Trade Analysis
- Defense Acquisition University MindRover/ Dragonfly
 - MAJ Keena's MindRover Tradespace Analysis
- Conclusions



Finding the sweet-spot among competing objectives (performance, unit cost, O&S costs, development risk, and growth potential) is a non-trivial task. Ultimate metric is **affordable mission success.**



Materiel and Tactical Employment are not separable in real world.





Early Synthetic Prototyping



ARCIC Early Synthetic Prototyping (ESP)

- MG Hix tasked LTC Vogt to setup a persistent game environment for Soldiers to play emerging technologies.
 - ARCIC is looking for >20 year out concepts for the Army to try out in a gaming environment
 - End state: 1000 Soldiers in **persistent** environment
- Initially pursuing robotic wingman concept as pilot study
- First person shooter environment to start (VBS3 currently)

Random Fact: After one month of the release of Call of Duty Black Ops, gamers accumulated 68,000 years of play.

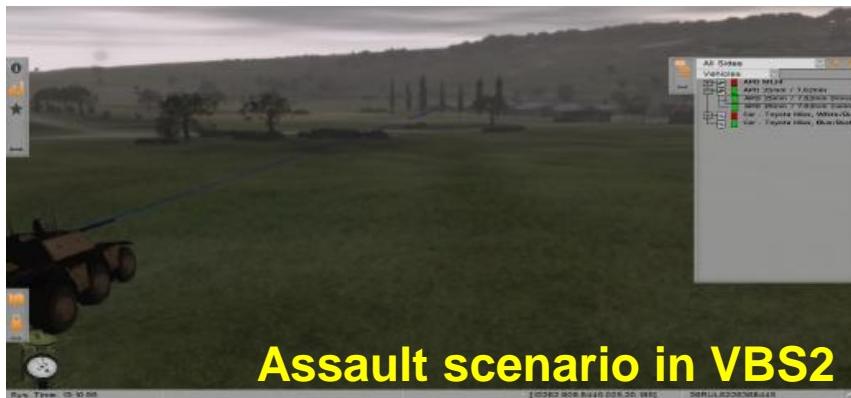




Early Synthetic Prototyping NPS Pilot Study: Robotic Wingman



- Robotic wingman based on actual demonstrator system
- Three scenarios:
 1. Track a red convoy (AI) to a specific location, then eliminate it. 4 blue
 2. Assault a defended, fixed location to free prisoners. 2 blue/ 2 red
 3. Defend an urban location for five minutes. 2 blue/ 2 red



Game Physics Based on
Autonomous Platform
Demonstrator

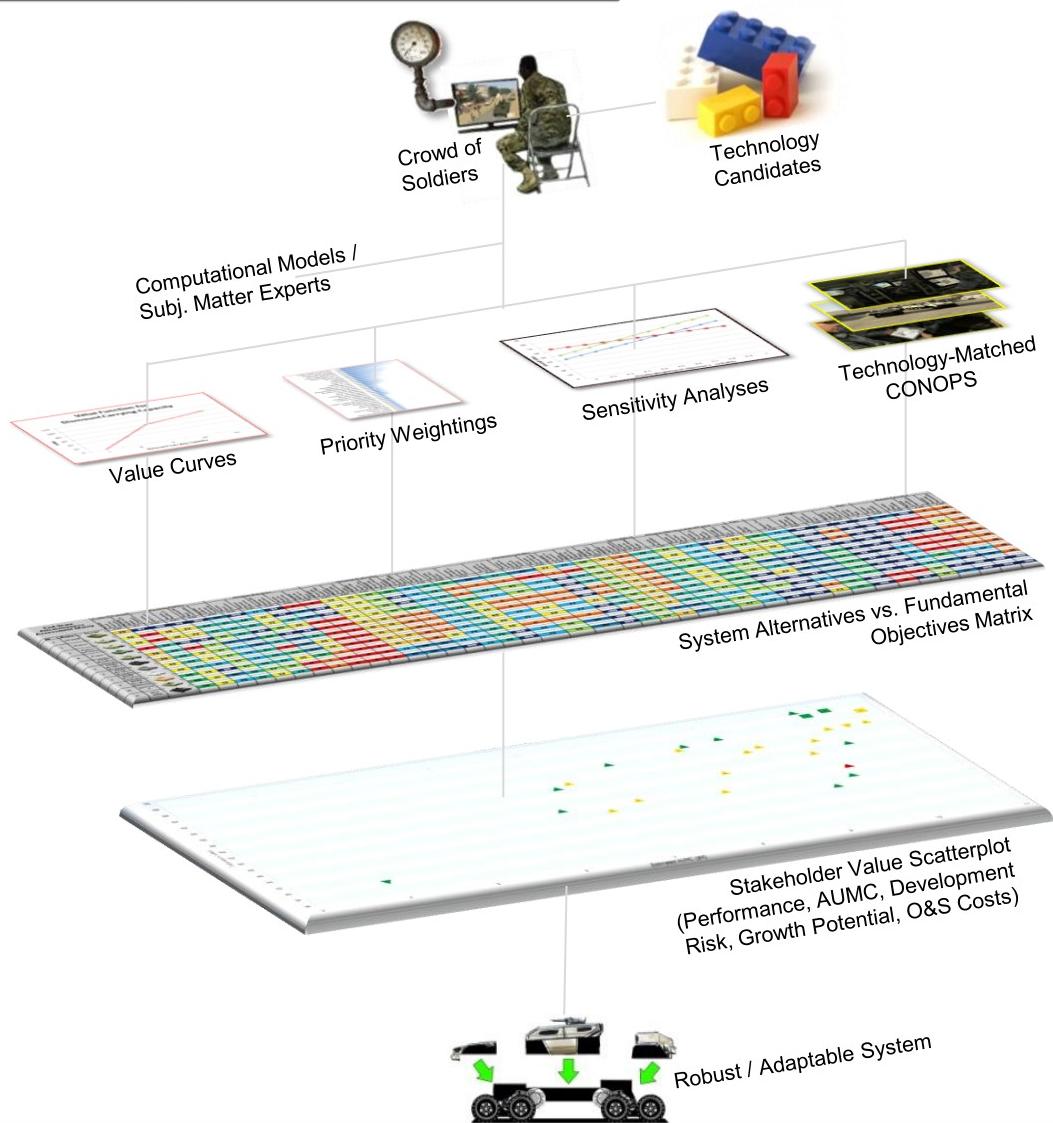


Big Takeaways:

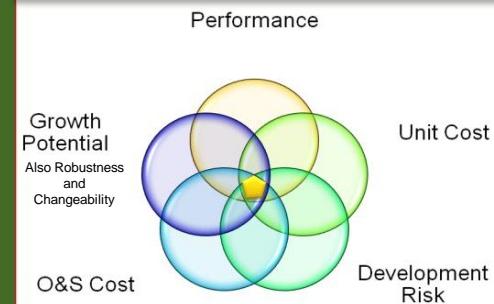
- Soldiers very enthusiastic about playing game – especially head-to-head
- Game interface is very important (which key does what)
- Scenarios showed definite desire to tailor platform for mission



Early Synthetic Prototyping: Systems Engineering Construct



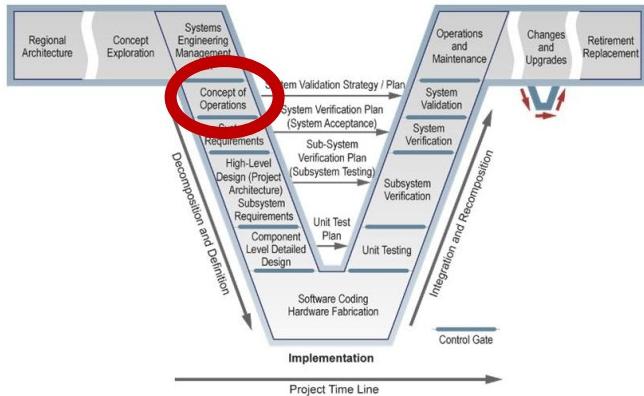
Elements of Stakeholder Value



Capture and synthesize analyses being conducted by Soldiers AND subject matter experts into visualizations designed to facilitate rapid and complete understanding of the trade-space to stakeholders and provide drill down capability to supporting rationale.



How do you develop a system if you do not know what it is supposed to do?



108 SE's surveyed:¹

- 36% never had CONOPS
- 73% did not complete CONOPS by program start
- 50% did not update CONOPS
- 30% did not involve a user

60 CONOPS examined:

- took 3-30 months to complete
- 25% did not state mission needs
- 80% did not discuss system risks
- 50% did not include operational scenarios
- 50% of IEEE or ANSI standard elements were not included

NOTE: CONOPS = Concept of Operation

1. Roberts, N., & Edson, R. (2008). *System Concept of Operations: Standards, Practices and Reality*. NDIA Systems Engineering Conference, San Diego CA.

2. Cloutier, R. et al. (2009). *Investigation of a Graphical CONOPS Development Environment for Agile Systems Engineering*: Systems Engineering Research Center. SERC-2009-TR-003.



Value of Digital Combat vs. "Magazine Racing"



Magazine Racing: Where you pull out the specs and never run the race.

Camaro SS 2010

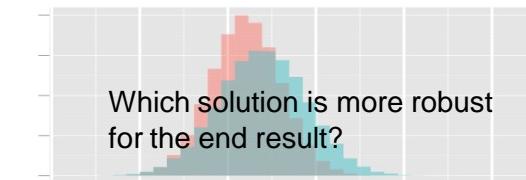
Engine: 6.2 Liter LS3
Power (SAE): 426 BHP @ 5900 RPM
Torque: 420 ft-lb @ 4600 RPM
Weight: 3,860 lbs

Mustang GT 2011

Engine: 5.0L V8
Power (SAE): 412 hp @ 6,500 rpm
Torque: 390 ft-lb @ 4,000 rpm
Weight: 3,605



DATA Based: Maintenance, weather, driver tactics, trans type, component durability, run-to-run variation, etc





Tactical Utility Concept



Major driver of **future** acquisitions is to maximize combat success at a minimal cost:

Tactical Utility = Mission Success / Total Cost

- Mission Success resiliency quantified by game data
- Total Cost = development, acquisition, future customization, maintenance, disposal

Future will bring tension between two extremes and solution robustness:

1. Mass produced, but adaptable / flexible via modularity
2. Custom specific purpose “disposable” vehicles



Closer Look at WSTAT Tradespace Exploration

Whole System Trade Analysis was developed by TACOM to identify relationship between high level design decisions & stakeholder value. Contact: Shatiel Edwards.

shatiel.b.edwards.civ@mail.mil



Legend

Development Risk

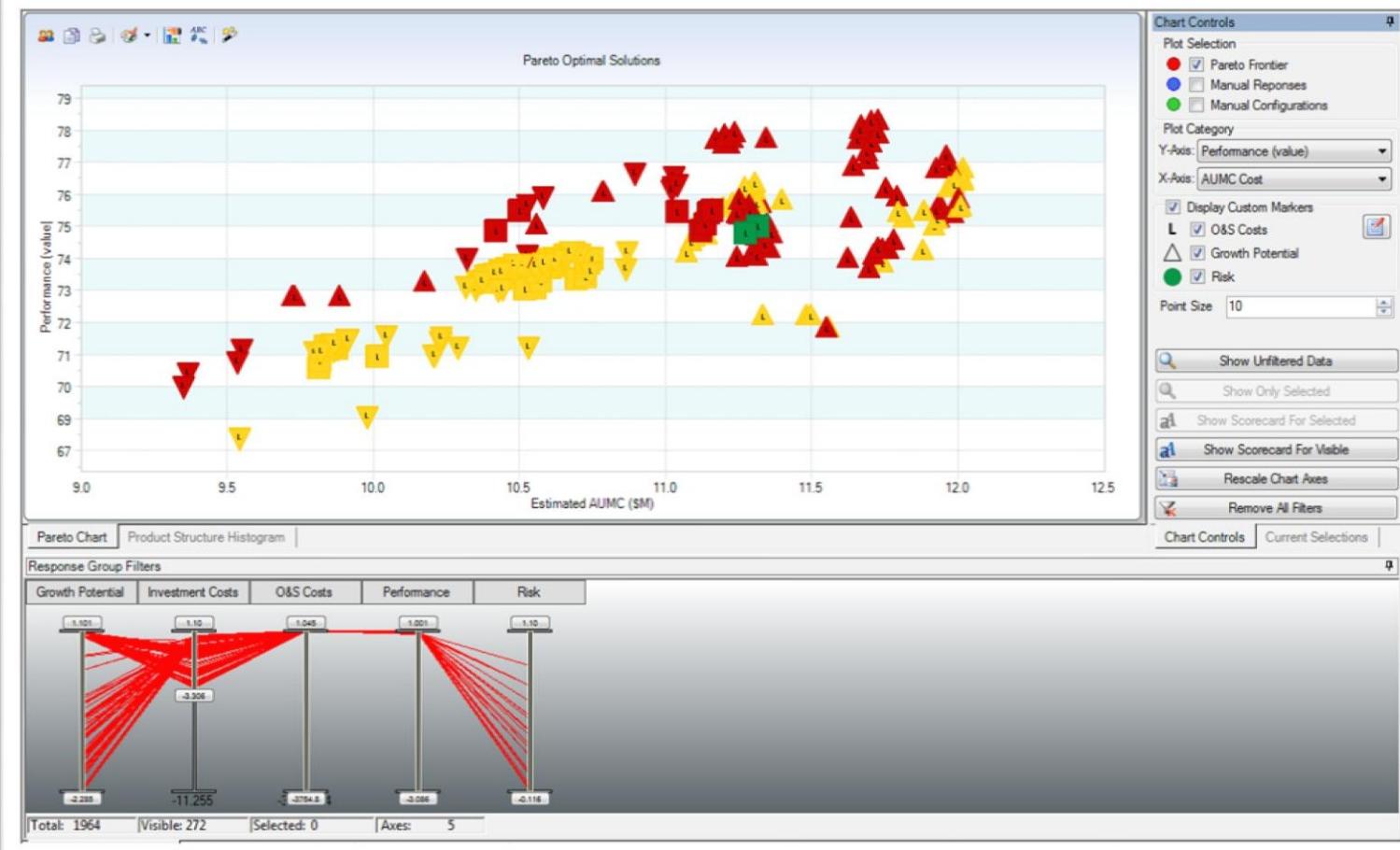
- High Risk
- Moderate Risk
- Low Risk

Growth Potential

- ▲ high growth potential
- moderate growth potential
- ▼ low growth potential

O&S Costs

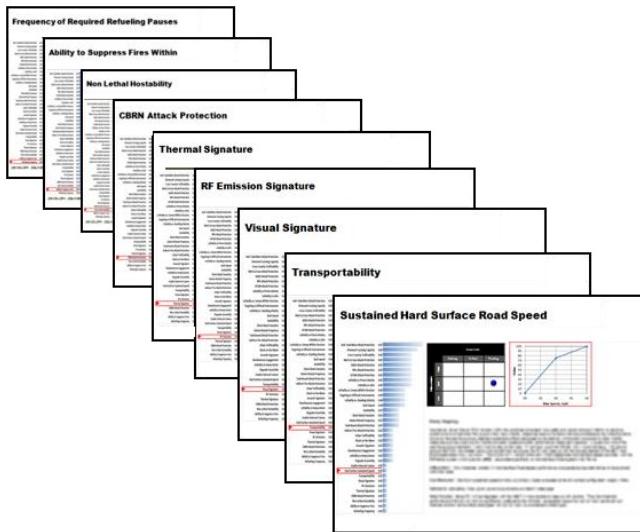
- High O&S Costs
- Moderate O&S Costs
- Low O&S Costs



The stakeholder value scatterplot synthesizes data to show each system alternative's response in dimensions of stakeholder value (unit cost, O&S cost, performance, development risk, growth potential)



Relative Feature Priority / Value Functions



Priority weightings and value functions for each objective are well reasoned based on SME input and gaming data.

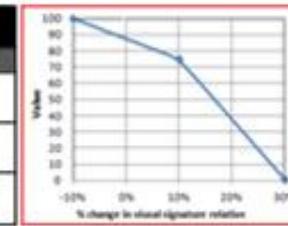
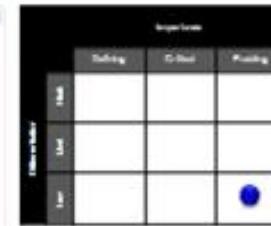
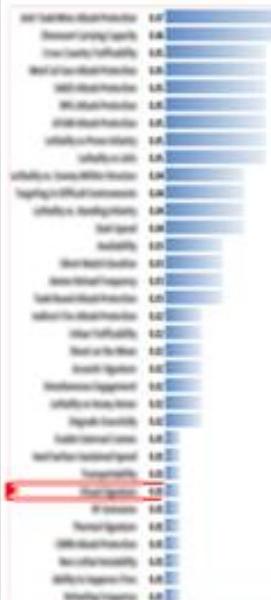
Relative Priority Weighting Indicator

Swing Weight Matrix
(Performance Gap vs. Importance)

Value Function
(knee in the curve)

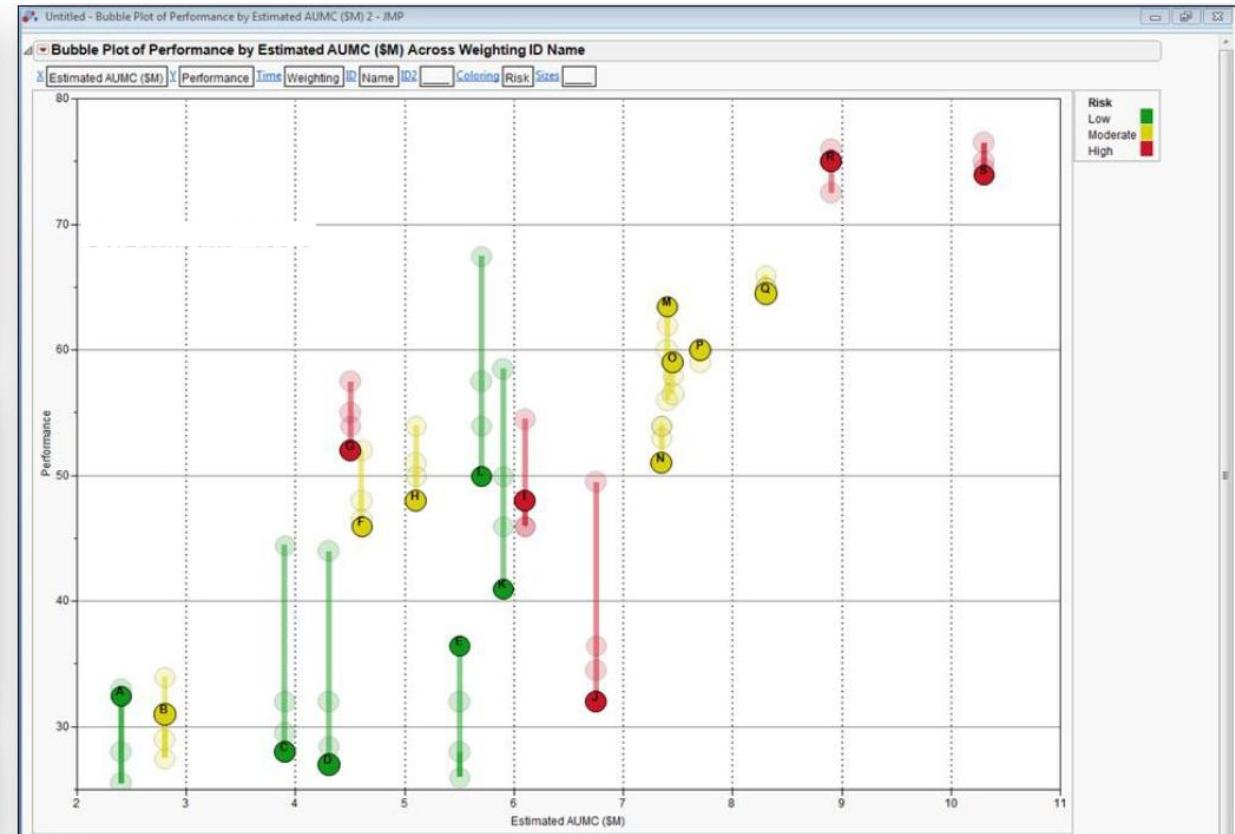
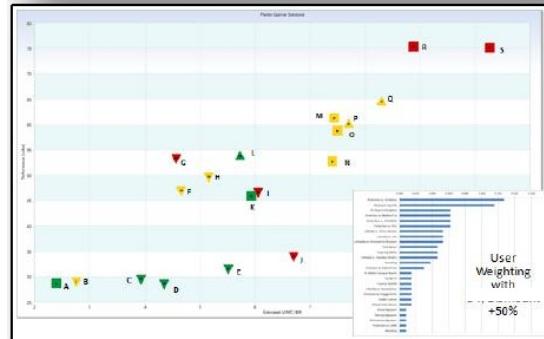
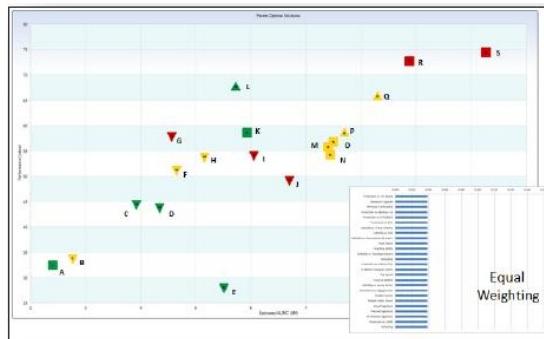
Supporting Narrative

Visual Signature





Sensitivity Analysis



Sensitivity analysis allows decision makers to see how performance values for each alternative move as priority weightings change.



ESP Crowdsourced Demonstrator: Defense Acquisition University's MINDROVER / DRAGONFLY



- PMT-352 Program Management teaching tool
- Ver 1: Mindrover based on commercial game
- Ver 2: Dragonfly simplifies the “wiring requirements” and tunes for teaching
- MAJ Keena example DOE using MindRover

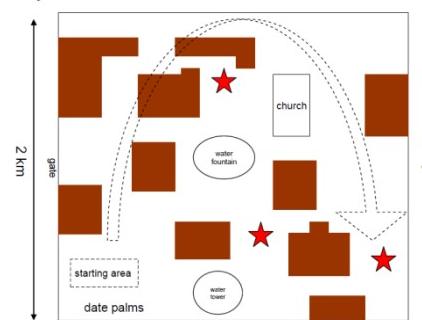
JRATS = (Joint Reconnaissance and Targeting System) robotic combat vehicle



Keena Study: Over 1400 MindRover Runs Using 14 ROTC Cadets



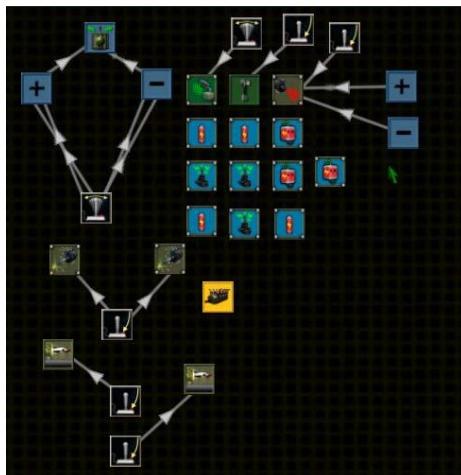
Move to Contact Urban Scenario



JRATS screenshot during contact. In this shot, the guided missile has drifted left of the laser and has missed the threat vehicle.



JRATS vehicle rendering of a completed tracked combat platform.



Design screen: Build components are placed on a virtual breadboard. Logic components and interface modules are wired together to form the functional combat platform prototype..

Very similar to SysML or DARPA's AVM META!

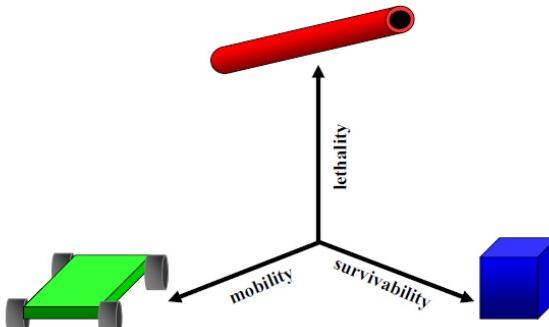


S	S
Acceptable Survivability rolled homogeneous (steel) armor aluminum body	Enhanced Survivability depleted uranium armor steel body

I	L
Acceptable Lethality 2× heavy machine gun laser range finder communications suite ground penetrating radar	Enhanced Lethality 2× guided missile pods 2× heavy machine gun laser range finder communications suite ground penetrating radar

m	M
Acceptable Mobility low output powerplant aluminum frame	Enhanced Mobility high output powerplant composite frame

- DOE with 18 variants
 - tracked vs wheeled
 - survivability 2 levels
 - lethality 2 levels
 - mobility 2 levels
 - 2 training vehicles
- 14 Operators
 - 15 missions per randomly assigned variants
 - Result = ~100 missions per vehicle
- 1600 ground vehicle missions



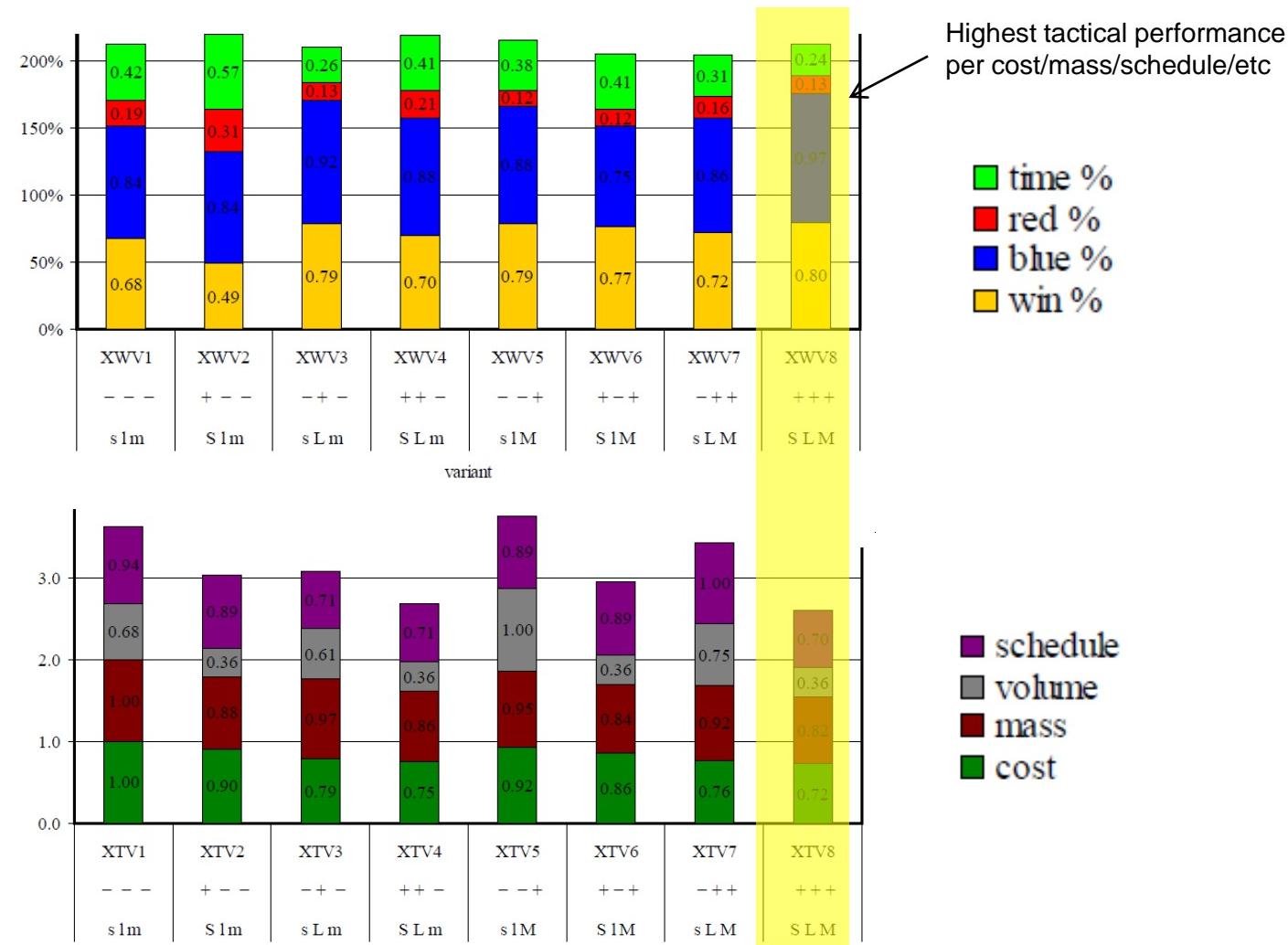
OUTPUT METRICS:

- rating of success or failure
- elapsed mission time (time mission)
- the friendly vehicle's remaining health (blue mission %)
- and threat vehicle's remaining health (red mission %)



Example Output Data

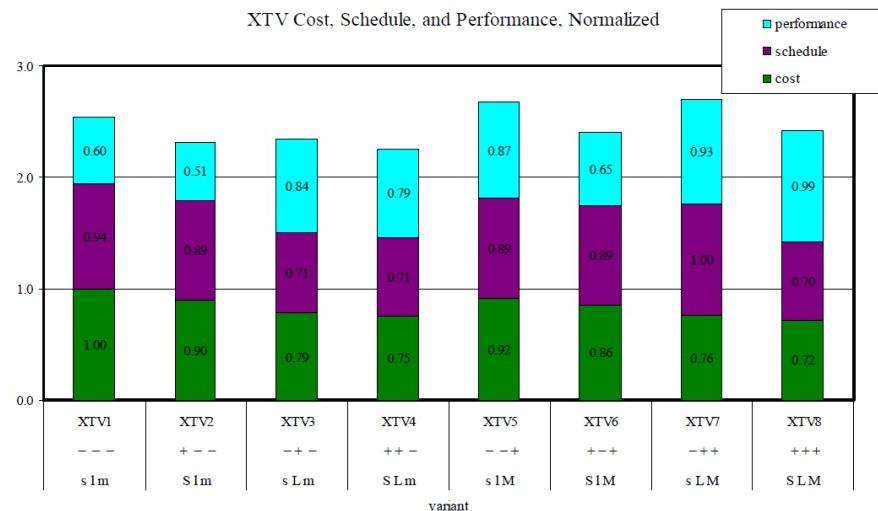
(Could be weighted/ normalized multiple ways)





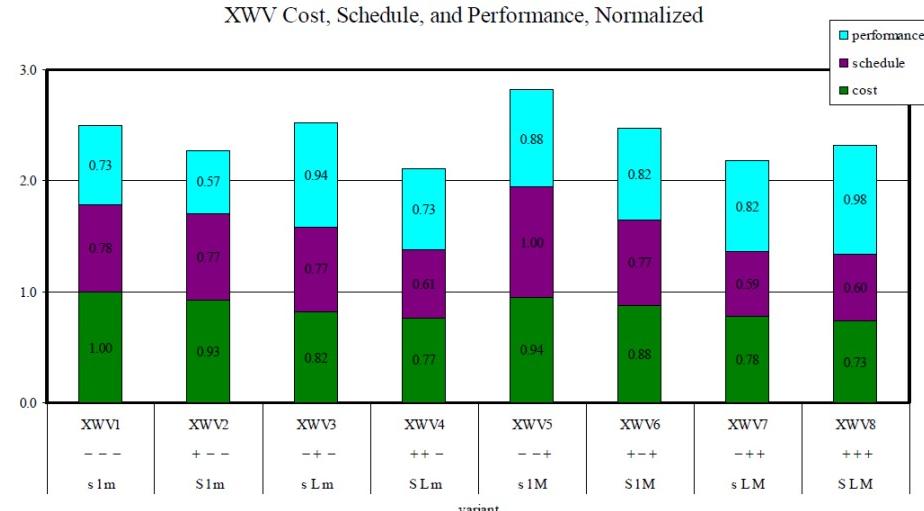
Tracked

XTV Cost, Schedule, and Performance, Normalized

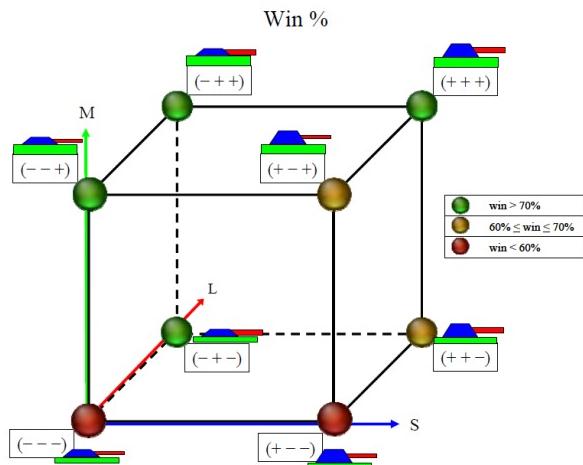


Wheeled

XWV Cost, Schedule, and Performance, Normalized



Performance is the sum of the normalized values for variant win %, blue %, red %, and time % divided by the number of *a posteriori metrics* (4). Cost is the per vehicle cost normalized with respect to the variant with the lowest per vehicle cost. Schedule is the normalized schedule index with respect to the variant with the lowest schedule index.



Average variant win record (XTV and XWV) in a survivability, lethality, and mobility domain. An XTV and XWV variant coincident at a point share the same relative levels of survivability, lethality, and mobility.

	Win % [%]	Blue % [%]	Red % [%]	Time % [%]
XTV	L 26	L 9	L 15	L 19
	M 19	S 2	M 13	M 12
	S 10	M 1	S 10	S 1
XWV	M 14	L 8	M 8	L 14
	L 8	S 2	S 4	M 8
	S 7	M 1	L 3	S 7

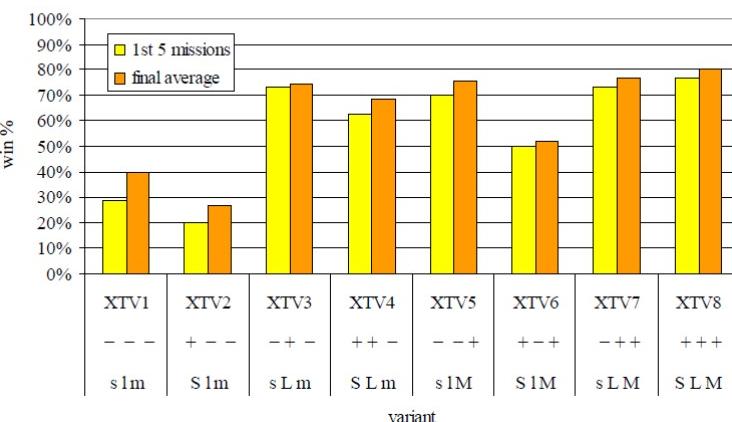
Effects of principal attributes on *a posteriori* performance metrics for XTVs and XWVs. A red bar indicates a negative effect on the metric, and a green bar indicates a positive effect on the metric. The length of the bar has been scaled in length with respect to the greatest effect for that metric in the XTV or XWV block.



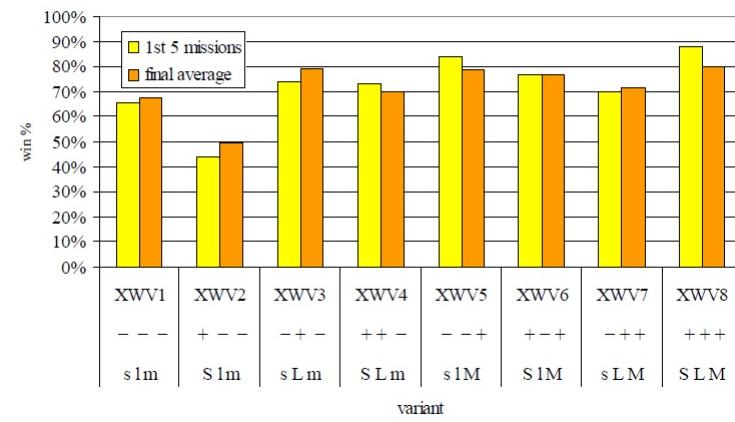
Learning Rate Vs. AI

- During training sessions group discussed tactics, techniques, and procedures (TTPs)
- Training missions conducted on tracked and wheeled training vehicle variants (TTV and TWV)
- Operators instructed to move in a clockwise fashion until the enemy vehicle was spotted
- Non-training sessions Win % calculated after just 5 missions versus final average at 15 missions per operator

TRACKED



WHEELED

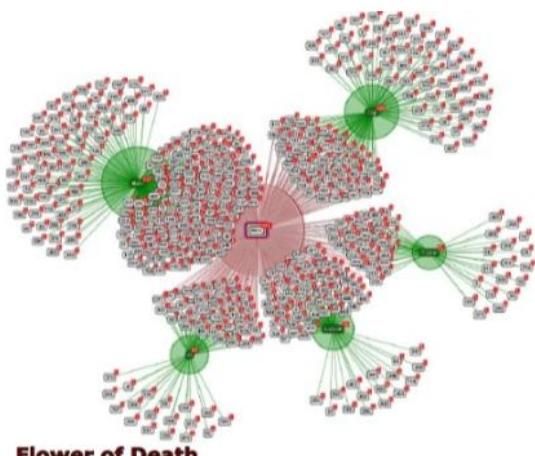
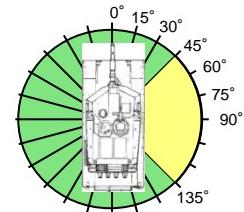


- Enhanced survivability platform had the greatest learning curve
 - Variant had the lowest mobility performance, with no gain in lethality
 - Operators presumably struggled initially to maneuver around the city
- Aside from the baseline variant (XTV1), all other variants had a learning curve less than 3%.

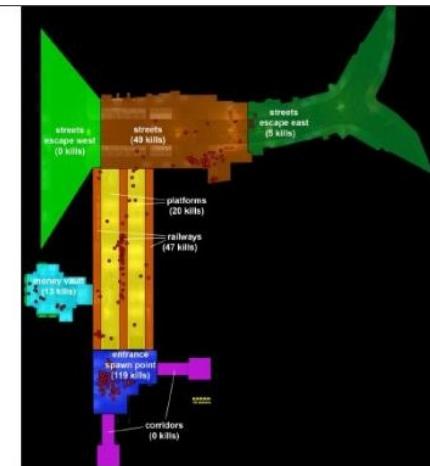
- Enhanced survivability platform had the greatest learning curve
 - Variant had the lowest mobility performance, with no gain in lethality
 - Operators presumably struggled initially to maneuver around the city
- Degradation in performance over time was seen for some variants
 - XWV8 experienced an over 5% drop in win % from first five to final 15 average
 - Possibly elevated baseline mobility enhanced even more for XWV5 and XWV8, caused operators to move in an ineffective or more "sloppy"
 - Suggests that the platform performance is directly effected by operators.



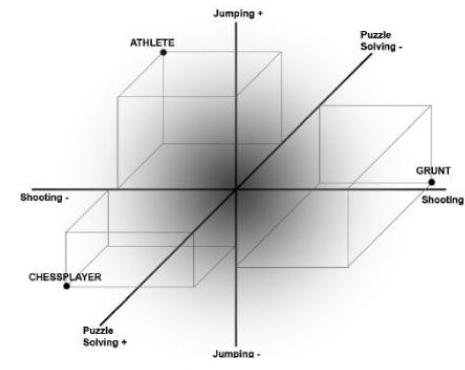
- Replays of winning tactics (directly obtained CONOPS)
- Discussion board chatter
- Sector engaged from in azimuth around vehicle
- Rounds expended
- How much available power and speed actually used



Flower of Death
Generated by a cluster visualization tool (shows data from *Fragile Alliance*, it relates **role** at death with **cause** of death)



Deaths in Sectors
Plotted deaths divided per sub-sector



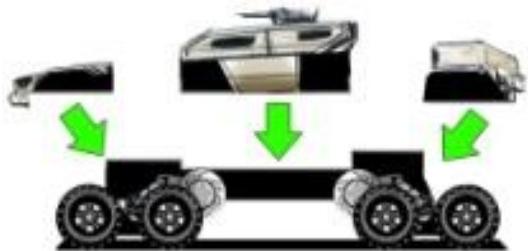
Play persona possibility space
Mapping the possibility space with play-personas



Enough Game Data Allows The Teasing Apart of Modularity and Customization Needs



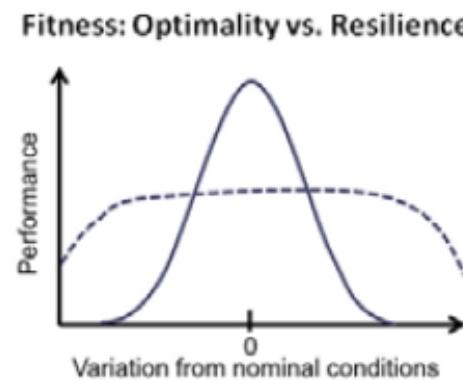
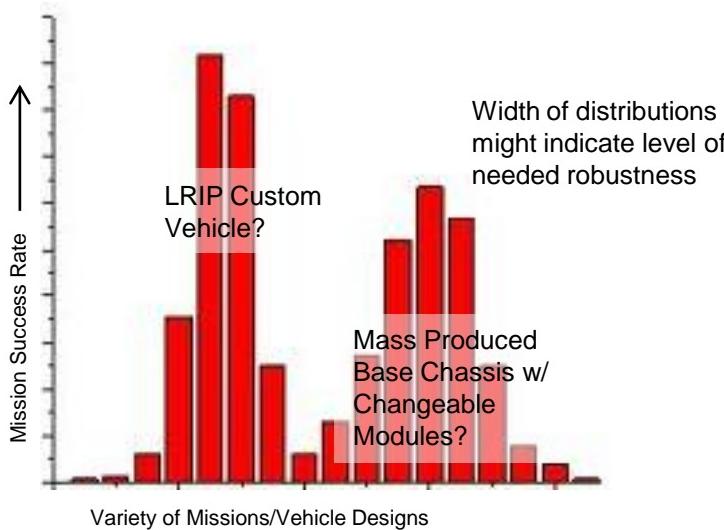
Which configuration elements can remain constant?



Which things need to be made modular?

Can a whole custom system be fabricated less expensively than a changeable system?

How robust is the solution in different scenarios?





Defense Acquisition University's DRAGONFLY Screenshots



- Dragonfly simplifies the “wiring requirements” and tunes for teaching
- Gives some clues as to complexity in a game for acquisitions



DragonFly ScreenShots (Formerly MindRover)





Parameters Tracked in Dragonfly

	FRACU	Scorpion	Mole
Vehicle Type	Hover	Tracked	Wheeled
Vehicle Size	Small	Medium	Large
Engine Size	Small	Medium	Large
Frame	Aluminum	Aluminum	Titanium
Armor	None	None	Steel
Power	Qty	Type	Qty
	3	Mk-III Batteries	1
			Mk-V Battery
			1 Mk-III Fuel Cell
			1 Mk-IV Generator
Electronic Components	Qty	Type	Qty
	1	Mk-I Targeting Laser	1
	1	Mk-I Radio Transmitter	1
	1	Mk-I Linear Mine Detector	1
	1	Mk-I Radar	1
	1	Mk-I Targeting Computer	1
			1 Mk-IV Electronic Countermeasure
Weapons	Qty	Type	Qty
	1	Mk-I Mini Gun	1
	1	Mk-I Laser Guided Missile	1
			1 Mk-I Machine Gun
			1 Mk-I Multi-Shot Free Rocket
			2 Mk-IV Free Rocket
			1 Mk-IV Multi-Shot Free Rocket
Properties	FRACU	Scorpion	Mole
	Weight (kg)	1266	1485
	Combat Survivability	230	275
	Idle Power (watts)	35	58
	Active Power (watts)	97	135
	Produced Power (watts)	105	135
	Acceleration (m/sec ²)	8	7
	Top Speed (kph)	25	14
	Length (m)	2.25	3
	Logistics Supportability Index (LSI)	2866	3085
Costs	Deployability Index (DI)	1741	1960
	Productivity Index (PI)	830	875
	Development	\$41M	\$60.5M
	O&S	\$1230M	\$1710M
	Procurement	\$615M	\$855M
	Unit Procurement	\$0.41M	\$0.57M
	Disposal	\$61.5M	\$85.5M
MILPERS	MILPERS	\$184.5M	\$256.5M
	Total	\$2132M	\$2967.5M
			\$4115.5M

UNCLASSIFIED



DragonFly ScreenShots



UNCLASSIFIED



DragonFly ScreenShots



DESIGN MODE: VEHICLE CREATION



CHOOSE VEHICLE TYPE



WHEELED



TRACKED



HOVER

CHOOSE VEHICLE SIZE

SMALL

MEDIUM

LARGE

VEHICLE DATA

COMPONENT SLOT CONFIGURATION



== Chassis Performance Statistics ==

Weight: 890 kgs
Survivability: 230
Idle Power: 25 Watts
Active Power: 32 Watts
Produced Power: 0 Watts
Acceleration: 8 m/s²
Top Speed: 25 kph
Length: 2.25 m
Logistics Index: 1600
Deployability Index: 475
Productibility Index: 600

== Vehicle Cost Statistics ==

Development Cost: \$18M
Operations And Support Cost: \$480M
Procurement Cost: \$240M
Unit Procurement Cost: \$0.48M
Disposal Cost: \$24M
MIL PER S Cost: \$72M

Total Cost: \$834M

== Chosen Chassis Options ==

Vehicle: Small Hover
Engine: Small Engine
Frame: Aluminum Frame

MAIN MENU

PRINT

✓ CREATE VEHICLE



DragonFly ScreenShots



DESIGN MODE: CHASSIS OPTIONS

ENGINE SIZE



SMALL

MEDIUM

LARGE

Small Engine Statistics:	
Weight	715 kgs
Survivability	180
Idle Power	10 Watts
Active Power	12 Watts
Max Speed	12 m/s
Acceleration	6 m/s ²
Development Cost	\$10.5M
Operations And Support Cost	\$280M
Procurement Cost	\$140M
Unit Procurement Cost	\$0.28M
Total Cost	\$1112M

FRAME MATERIAL



ALUMINUM

COMPOSITE

TITANIUM

Aluminum Frame Statistics:	
Weight	310 kgs
Survivability	75
Max Weight	5000 kgs
Development Cost	\$13.5M
Operations And Support Cost	\$360M
Procurement Cost	\$180M
Unit Procurement Cost	\$0.35M
Disposal Cost	\$18M
MIL PER S Cost	\$54M
Total Cost	\$1112M

ARMOR TYPE



NONE

STEEL

TUNGSTEN

No Armor Statistics:	
Weight	0 kgs
Survivability	0
Development Cost	\$0M
Operations And Support Cost	\$0M
Procurement Cost	\$0M
Unit Procurement Cost	\$0M
Disposal Cost	\$0M
MIL PER S Cost	\$0M
Total Cost	\$0M

VEHICLE DATA

IDLE POWER	MAX POWER
POWER	AVAIL.
WEIGHT	LIMIT

Chassis Performance Statistics

Weight	925 kgs
Survivability	255
Idle Power	32 Watts
Active Power	38 Watts
Produced Power	0 Watts
Acceleration	6 m/s ²
Top Speed	12 kph
Length	3 m
Logistics Index	1600
Deployability Index	475
Productability Index	600

Vehicle Cost Statistics

Development Cost	\$24M
Operations And Support Cost	\$640M
Procurement Cost	\$320M
Unit Procurement Cost	\$0.64M
Disposal Cost	\$32M
MIL PER S Cost	\$96M
Total Cost	\$1112M

MAIN MENU

PRINT

SAVE VEHICLE

CUSTOMIZE CONTROLS

▶ SELECT COMPONENTS

▶ LAUNCH TEST

UNCLASSIFIED



Vehicle Configuration



DESIGN MODE: COMPONENT SELECTION



NOTE: RIGHT CLICK TO CHANGE MARK NUMBER

POWER

ELECTRONICS

WEAPONS



VEHICLE DATA

PREVIEW

■ IDLE POWER ■ MAX POWER
POWER [progress bar] AVAIL.

WEIGHT [progress bar] LIMIT

Vehicle Description:

The hovercraft is able to traverse water, giving it a distinct terrain advantage over the other vehicles. However, it has a low durability and cannot carry as much weight as the other vehicles. The hovercraft has the most component slots of the chassis types and is capable of rapid rotation and agile movement, making it ideally suited to recon missions or when you need to dodge incoming fire.

SELECTED COMPONENT



Laser-Guided Missile

Weight	44 lbs
Active Power	8 Watts
Idle Power	1 Watts
Damage	80
Ammo	35 rounds
Penetration Rate	***

MAIN MENU

PRINT

SAVE VEHICLE

CUSTOMIZE CONTROLS

◀ CHASSIS OPTIONS

▶ LAUNCH TEST

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Virtual Field Test



The screenshot displays a 3D perspective view of a snowy, mountainous terrain. A central objective marker is highlighted in red. The map includes several labeled points of interest:

- INTEROP ACTIVE (red dot)
- INTEROP PASSIVE (green dot)
- MINE DETECTION (blue icon)
- SEEK AND DESTROY PASSIVE (blue icon)
- SEEK AND DESTROY ACTIVE (blue icon)

On the left side of the screen, there are two vertical status bars: "HEALTH" (red) and "POWER" (grey). Below these bars is a text overlay: "Press 'M' to toggle Map" and "Press 'TAB' to return to design mode." On the right side, there is a circular "Vehicle Test" interface showing a tree and a green circle with an arrow. At the top of the screen, a compass rose indicates directions: NNE, NE, ENE, and E. In the bottom right corner, there is a "MISSION TIME" indicator showing "07:01".

On the far left and right edges of the main map area, there are vertical panels containing control buttons. The left panel contains:

- Button 3 (missile icon)
- Button 2 (film reel icon)

The right panel contains five buttons labeled Button 4 through Button 8, each with an icon and an "OFF" / "ON" switch:

- Button 8 (robot icon)
- Button 1 (target icon)
- Button 6 (monitor icon)
- Button 5 (brain icon)
- Button 7 (Wi-Fi icon)

UNCLASSIFIED

30



"Mission Load" screen for "Field Test" test mode



MISSION LOAD

BRIEFING

Seek & Destroy (Passive)

The students must locate and destroy 3 moving AI and 1 target building. The AI would not be hostile.

SELECT MISSION

SUCCESS/ ATTEMPTS	MISSION TYPE
0/0	SEEK & DESTROY (PASSIVE)
0/0	SEEK & DESTROY (ACTIVE)
0/0	INTEROPERABILITY (PASSIVE) SINGLE FIREBIRD AC-130 MULTIPLE FIREBIRDS
0/0	INTEROPERABILITY (ACTIVE) SINGLE FIREBIRD AC-130 MULTIPLE FIREBIRDS
0/0	MINE DETECTION

MAIN MENU **VIEW REPORTS**

Start the selected Mission

START MISSION

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Field Reports



REPORT LIST

- Mine Detection
- Seek and Destroy - Passive
 - 05-23-2010, 12:22:56
 - 05-23-2010, 12:26:06
- Seek and Destroy - Active
- Interoperability - Passive
- Interoperability - Active

◀ BACK

PRINT SELECTED **PRINT ALL**

FIELD REPORTS

Seek and Destroy - Passive 05-23-2010, 12:26:06

Start Time:	05-23-2010, 12:26:06
Elapsed Time:	07:40
Remaining Time:	07:20
Successfully Completed:	yes
Player Health:	100%
Enemy Vehicle 1 Health:	0%
Enemy Vehicle 2 Health:	0%
Enemy Vehicle 3 Health:	0%
Enemy Building Health:	0%

SUMMARY

The students must locate and destroy 3 moving AI and 1 target building.
The AI would not be hostile.

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Conclusions



- Pilot studies indicate it is possible to get useful data from virtual combat (i.e. games)
 - Have only scratched the surface on true utility of this
- 21st Century Blitzkrieg requires tactics and materiel be tightly coordinated
 - Alternative is 21st century Maginot Line
- Crowdsourced gaming might provide enough data to allow acquisitions to understand growth, modularity, and maybe custom vehicle needs
 - Maximize tooth, minimize tail